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Mitigation of long-term bed degradation in rivers: set-up of research

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Introduction

Sediment management measures are becoming increasingly popular as they are considered sustainable from both economic and environmental point of view. For example, aimed at counteracting river bed degradation, sediment nourishments have been carried out in the German reaches of the Rhine river while a nourishment pilot study has recently taken place at the Dutch Rhine and a nourishment project has been scheduled for the Danube by the Austrian water management authorities. Moreover, sediment management measures are implemented in various ecological restoration projects (e.g. Trinity river in U.S. and Nunome river in Japan) as sediments and their characteristics form the habitats of the biota, as well as in river training projects around the world.

Bed degradation is the dominant morphodynamic response of the freely flowing part of the Rhine river to past centuries' river training focused on navigation and flood protection. It threatens almost every aspect of river management such as navigation, ecology, and existing infrastructure (Gölz 1994). Re-allocation dredging by means of by-passing and dumping of dredged sediment from shallows to deeper locations, combined with nourishments of artificial sediment have been the main mitigation practices taken on by the German river management authorities since the mid-70s to counteract this problem (Frings et al. 2014 a,b).

Such nourishments at one hand partly restore the deficit of sediment caused by its retention at upstream basins from canalization and impoundment of major tributaries. Furthermore, the relatively coarse sediment nourished –compared to the bed surface sediment- has a stabilizing effect by armouring of the bed surface, yet tends to cause degradational problems downstream (Gölz 1994, Blom 2016). This is also demonstrated by an experimental study carried out under laboratory conditions shown in Fig. 1.

A sustainable design of such mitigation measures calls for (a) an assessment of the ongoing adjustment of the river bed and (b) the use of numerical tools. Such numerical tools need to be based on conservation laws and account for the dominant morphodynamic processes i.e., grain size selective transport and abrasion which induce sorting patterns in all directions and shape the river's longitudinal profile (Mackin 1948, Blom et al. 2016). The validation of such numerical models is not a trivial task. Sets of measured field data are available, yet an assessment is needed on how to effectively validate such models.

Objective

The main objective of the research presented here is to assess the short and long term effects of sediment management measures on the river's profile and optimize the mitigation practices by addressing predominantly the volume, characteristics of mixtures, frequency, locations, timing and duration of nourishments.

General approach

The research will proceed by means of literature survey, analysis of available datasets and numerical modelling. Fig. 2 illustrates the method of the research. The first step to be taken is the identification of the current mitigation practices and a preliminary assessment of their effects based predominantly on literature survey and data analysis. Later, numerical models appropriate for simulating mitigation measures for different temporal and spatial scales will be setup and validated. These numerical tools will then be used to assess the short and long term effects of sediment management measures using cases of varying complexity. The design of such measures will be carried out with different sediment supply and water discharge scenarios as well as with the use of probabilistic analysis to address the uncertainty. Interactions of sediment management measures and other commonly implemented river management practices (e.g. Room for the River, replacement of groynes by longitudinal dams) will also be studied.

Future work

The preparation of the workplan is at its final stage, and a preliminary study on the morphodynamic temporal trends in the freely flowing Rhine has been carried out. The next step is to extend the latter step to other rivers where sediment augmentation measures have been conducted, as well as to select appropriate numerical tools.

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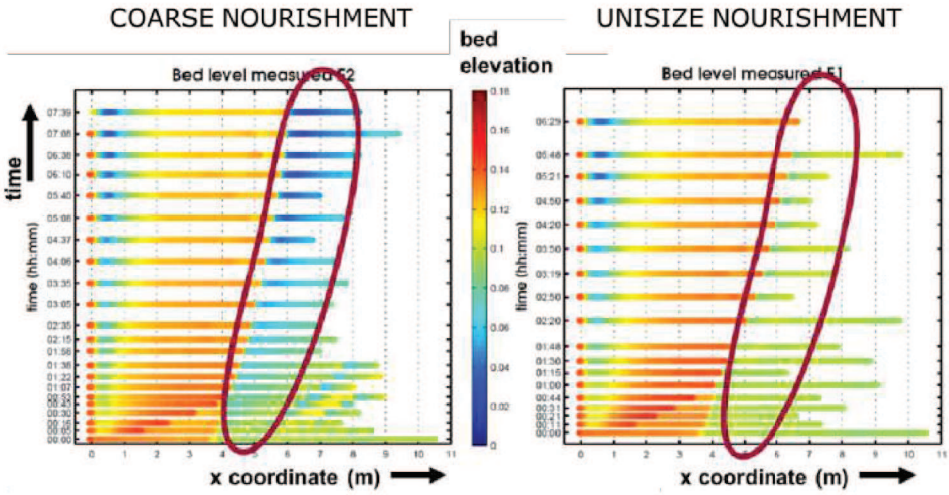

Figure 1: Laboratory experiment with nourished sediment located at x = 0 and x = 3.5 m at time 0 for two cases (nourished sediment coarser than bed surface sediment (left) and unisize compared to bed surface sediment (right). In a case of coarse nourishment degradational wave is migrating downstream considerably faster that the nourished sediment. (from Blom 2016*)*

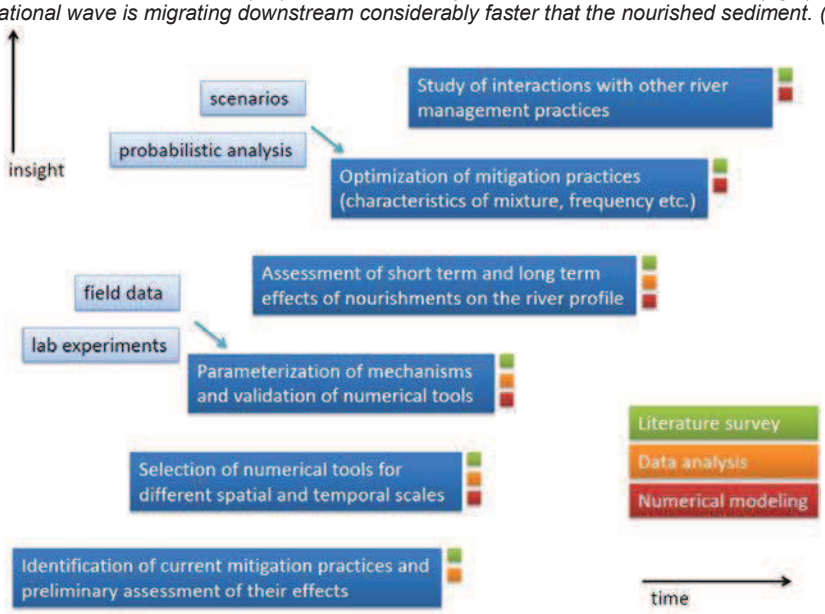

Figure 2: Workplan of research project.